SWEG/JIMM C² Processing and Application for Decision Support at the JFACC Level and Below

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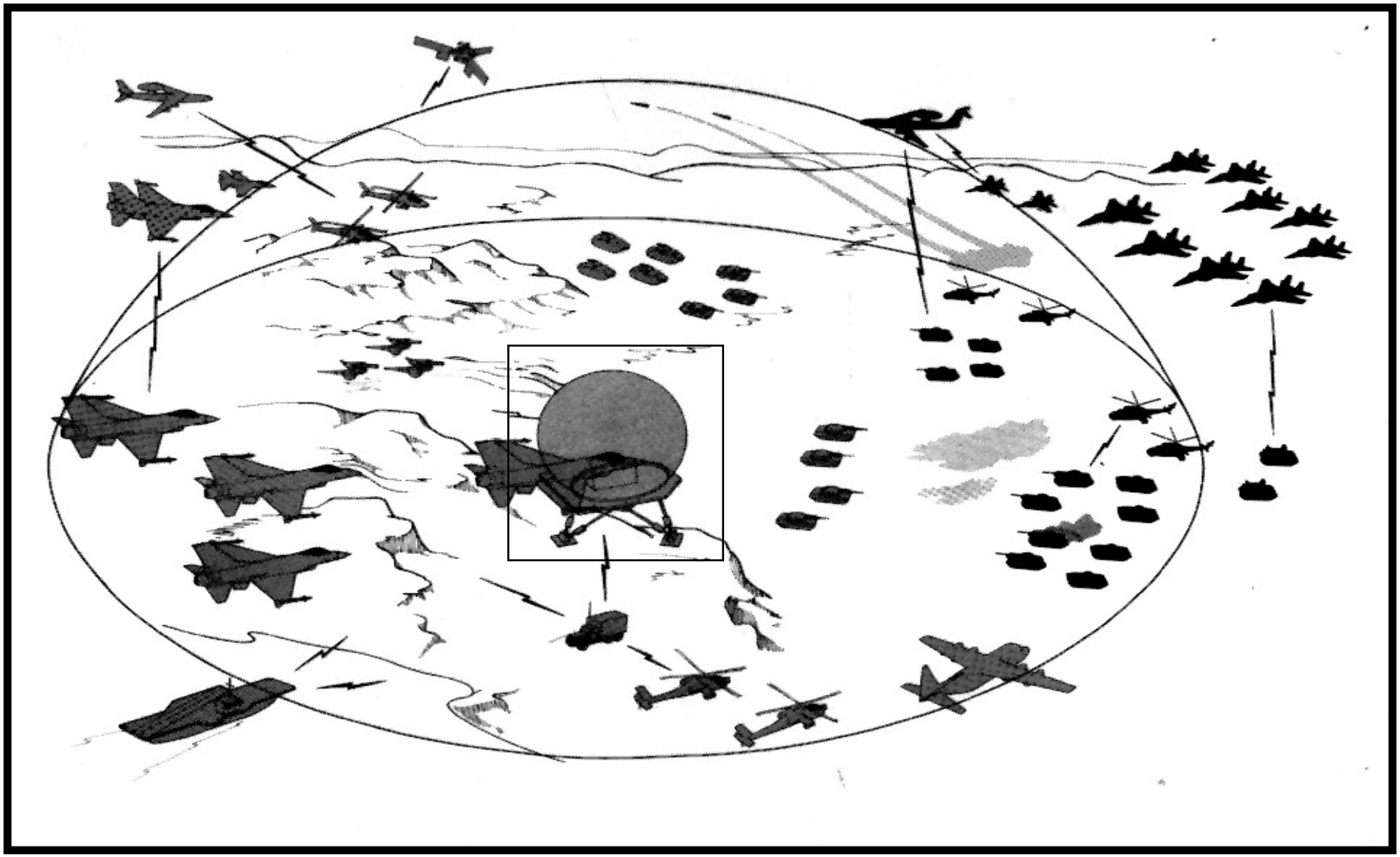
Purpose

- **To Describe the C2 Processing in the Joint Interim Mission Model (JIMM) and the Simulated Warfare Environment Generator (SWEG)**
- **To Discuss the Application of this Technology to Support Decision Making at the JFACC Level and Below:**
  - **Long Range Planning**
    - **Decision Tools for Warfighters**
    - **Requirements Analysis**
    - **Simulation-Based Acquisition**
    - **Test & Evaluation**
  - **Course of Action Analysis**
    - **Training & Operational Concepts Development**
  - **Campaign Modeling**

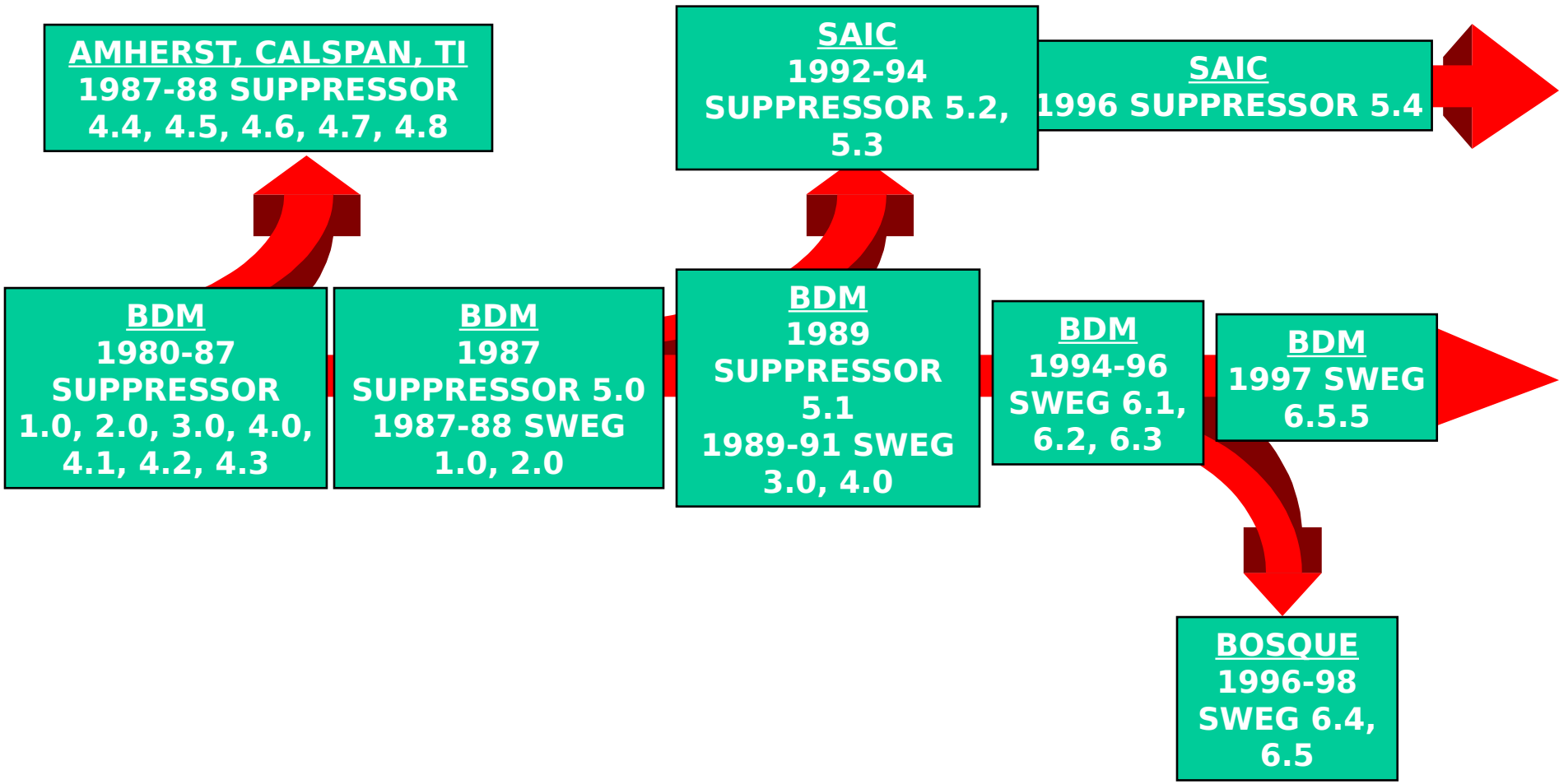
Agenda

- Quick Intro
- Overview of JIMM & SWEG
- C2 Process Modeling
- Decision Support Tool
- JIMM Demonstration

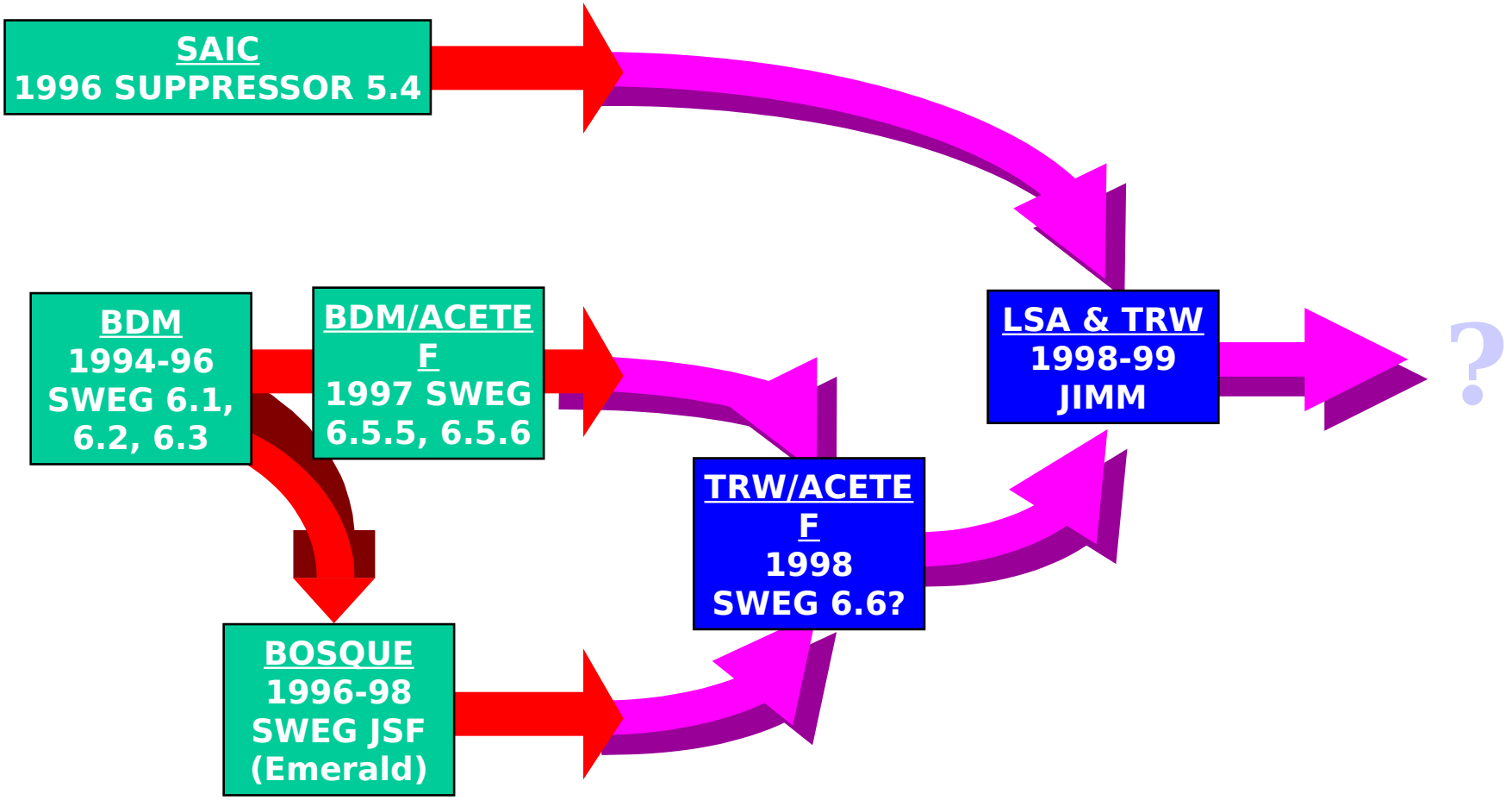
SWEG/JIMM - Next Generation Mission



SWEG - SUPPRESSOR History



SWEG - SUPPRESSOR Future



What is JIMM?

- **JIMM is a data driven, event-stepped general purpose conflict simulation system.**
- **This simulation system can be used as a reactive scenario generator to analyze mission level conflicts either standalone or in unison with external simulations, simulators & stimulators.**
- **JIMM is an interim fix to modeling challenges within the Joint Strike Fighter (JSF) program**
- **JIMM is a merger of SWEG & Suppressor**

High Fidelity Mission Modeling

Define the Scenario

- Define the Environment
- Define the "Players"
  - Properties & Behaviors
  - Interactions & Responses
- Define the Interactions Between Players

JIMM Makes Tactical Behaviors Adaptive, Not Fixed

Run the Model

Collect and Analyze the Data

Military Example

Define the Terrain
Define the Platforms
- Signatures
- Communications
- Sensors
- Guns
- Tactics
- Responses

Define the Interactions
Run the Simulation
Capture the Data
- Sensor Hits
- Tactical Responses
- Shots and Kills

Compare with Results from Other Design/Tactical Choices

What is a Player?

- **A player represents, to some degree of fidelity, things that exist in the real world.**
- **Players are the mapping from the ambiguous real world to structures that make the simulation of a conflict possible. A player can represent a single entity or a collection of entities.**
- **Users employ the JIMM Conflict Language to describe players, and the relationship between players. The level of detail used to explicitly represent a player is up to the user. The detail chosen is typically dependent upon the analysis factors required in the simulation.**

Generic Mission Modeling Functions

- **Six Basic Functions Represent the Processes Involved in Conflict:**
  - **Sense (IR seeker, acquisition radar)**
  - **Talk (mobile radio, microwave relay)**
  - **Shoot (missile, bomb)**
  - **Disrupt (jammer, flare)**
  - **Move (aircraft, submarine)**
  - **Think (pilot, staff section, computer)**
- **Significant Features:**
  - **Signature (RCS, presented area)**
  - **Tactics (orders, SOP)**

Object Oriented Structure

Associate Data/ Parameters with Model Entities

Flexible, Adaptive Behavior

Sens
e

Sensing drives the simulation. Physical aspects of sensing are separated from the mental aspects (noticing and digesting).

- Seeker errors and sensor errors (Std. Dev
- Types: radar, IR, optical, acoustic, and warning receiver
- User specifies antenna pattern, power, sensitivities, losses, calibration parameters, tracking probabilities (both cued and uncued), polarization, MTI / ECM effects, PRF, frequency, duty cycle, etc.
- Not a detailed pulse-to-pulse model; multipath and glint / scintillation not modeled; clutter and deception are modeled to some extent.

Examples of Players

	M1A1 Troop Cdr	M901 Mortar	FIST-V	MT-LB	2S1 SPH Battery	AH-64	JSTARS	ELINT Satellite	Cruiser	SAM System	Missile
Sensor(s)	4	1	3	1		2	2	2	16	2	1
Communicator(s)	2	2	2	1	1	1	1	1	3	3	1
Mover(s)	1	1	1	1	6	1	1	1	1		1
Weapon(s)	1	1			6	2			9	1	1
Disruptor(s)	1			1					6		
Noticer(s)	3	2	2	1	6	1	1	1	10	3	1
Digester(s)	3	2	2	1	6	1	1	1	10	3	1
Reacter(s)	3	1	2	1	6	1			9	3	1
Ponderer(s)	1	1	1		6	1	1		1		1
Reviewer(s)	3	2	2	2	6	1	1	1	10	3	1

Thin
k

The thinking function provides the capability to realistically model human behavior at a reasonable level of fidelity in a mission-level simulation.

- Alpha-Beta data fusion available
- Notice, digest, react, review, ponder and adapt are the basic thinking sub-functions
- User specifies time delays for each thinking activity
- Capability to evaluate and rank the accuracy of intelligence data by perceived data item

JIMM - Cognition Model

Plan measures progress towards goals and assesses the need for changed strategy.

Review evaluates the quality and quantity of information. It may throw away perceptions, draw conclusions, request action.

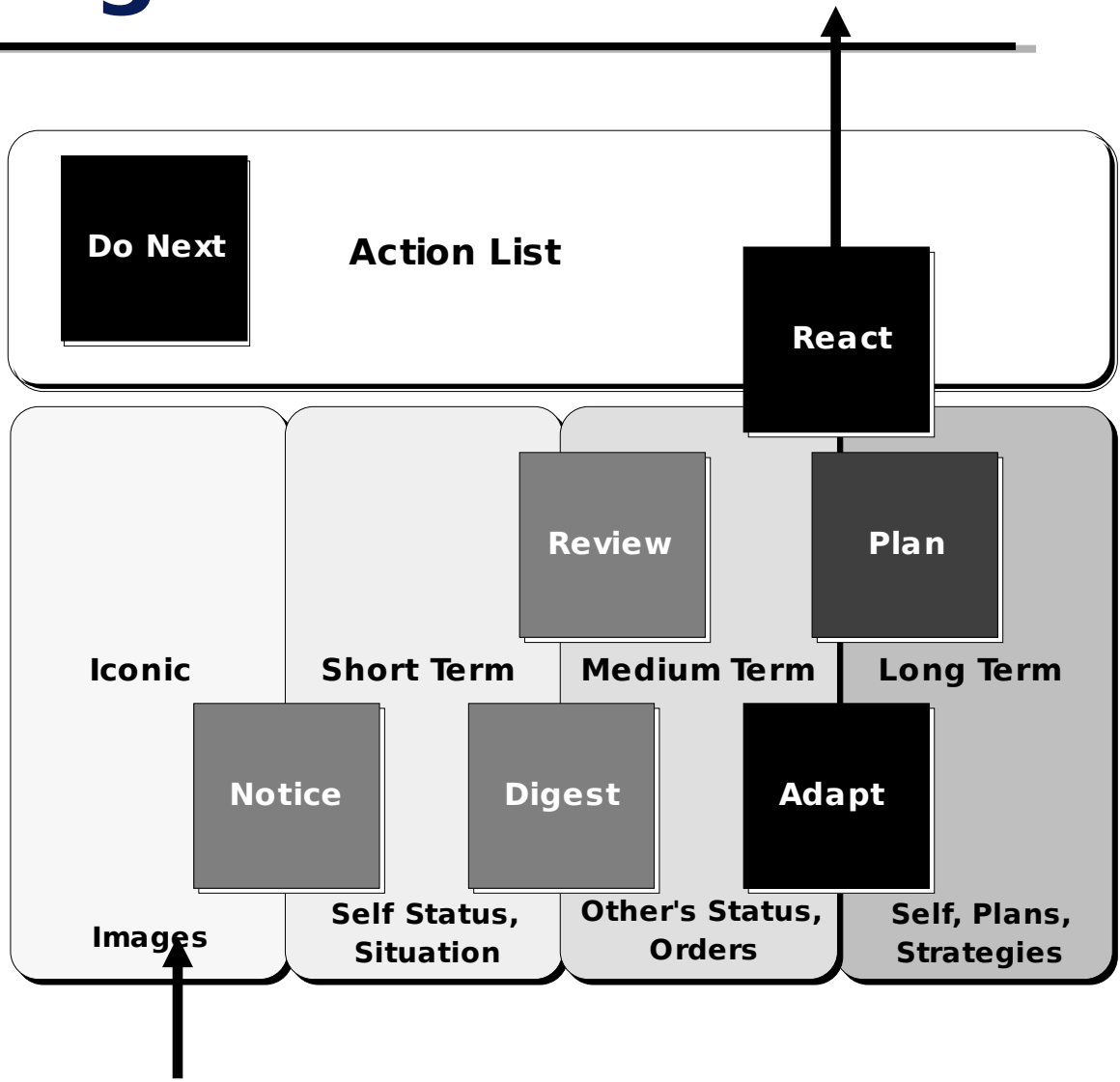
Adapt alters the way the entity evaluates & reacts to situations.

React manages the entity's and subordinate's physical resources.

Notice filters information to short term memory based on entity activity.

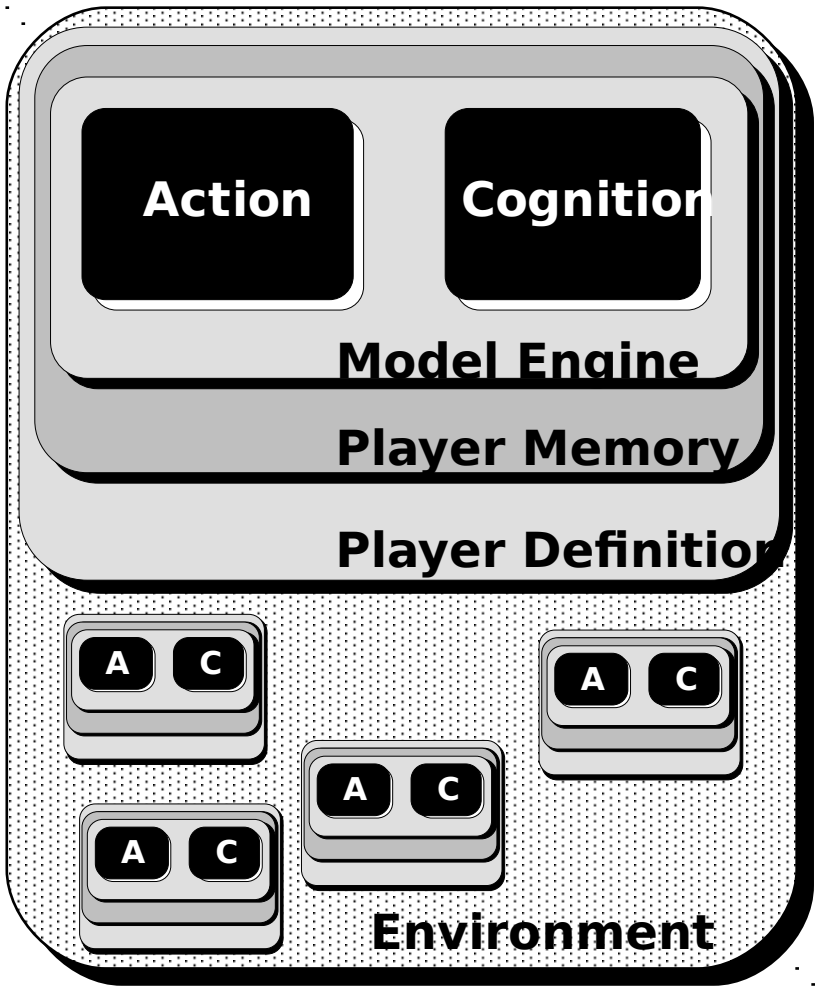
Digest moves information to medium term Memory.

Do Next allocates time to the other six objects and manages the action list.



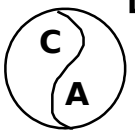
JIMM - Internals

- Action Object deals with physical phenomena: move, shoot, communicate, sense, jam, etc.
- Cognition Object deals with perceptual phenomena: notice, digest, react, review, plan & adapt.
- Each player is defined by attributes such as capabilities (sensor antenna pattern, fuel usage, etc.), susceptibilities (signatures, Pk tables, etc.), and tactics (rules of engagement, formations, etc.).
- Each player is maintained as its memories: its knowledge of its relationships to other players,



Entity Representations

Vehicles, command elements at all echelons, terrain and weather objects, and other battlefield entities are explicitly and separately represented in the computer generated forces (CGF) engine.

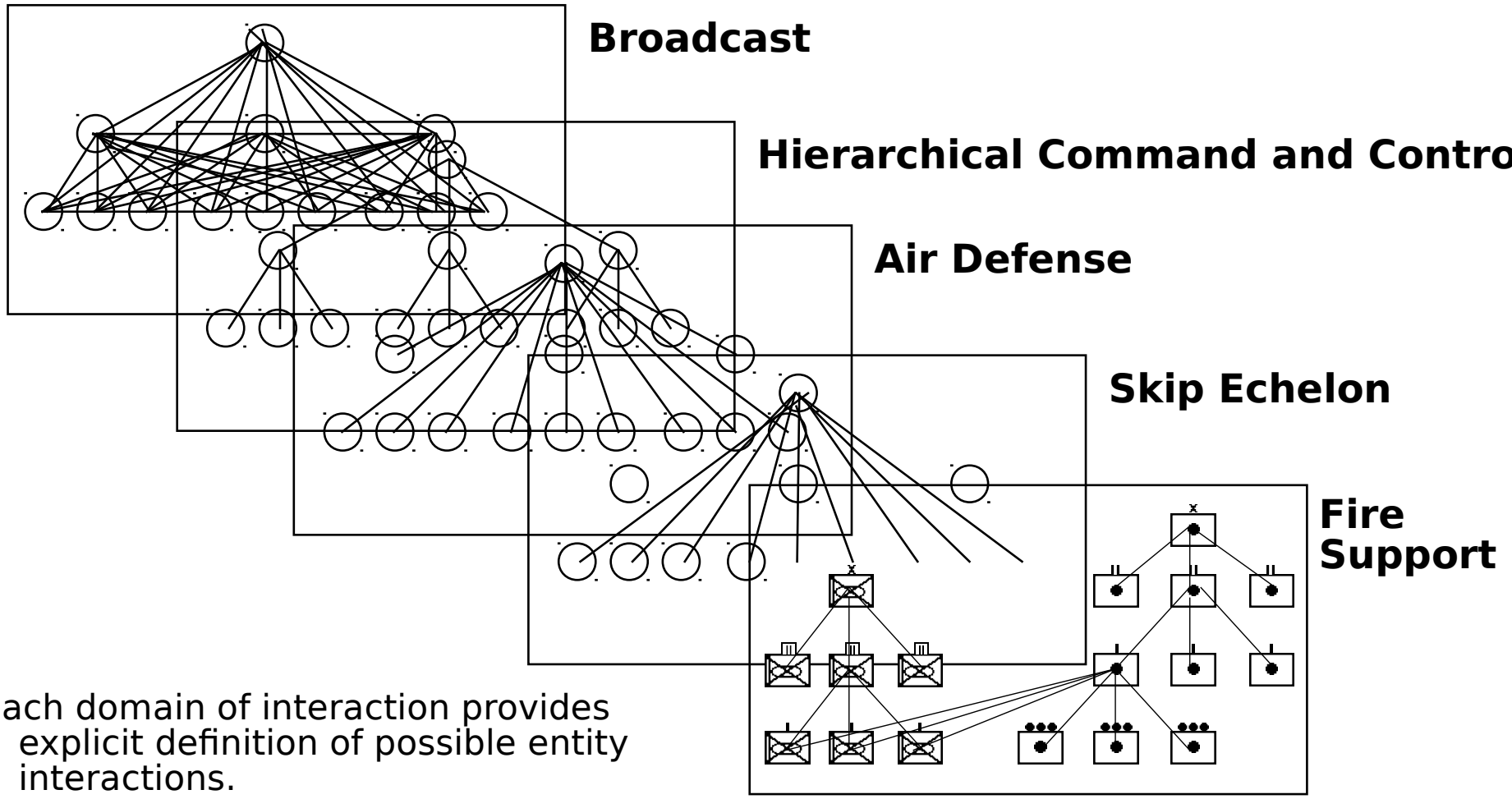


Entities are represented by models, manned simulators, or equipment. Our basic building block for modeled entities is a *cognition and action* object pair (c/a) which may be joined with other elements as appropriate. This building block is part of JIMM.

The cognition object deals with perceptions of the battlefield and the action object deals with the physics of the battlefield.

Other models, equipment, or men in the loop may be used in combination with this couple to represent entities.

Some Domains of Interaction

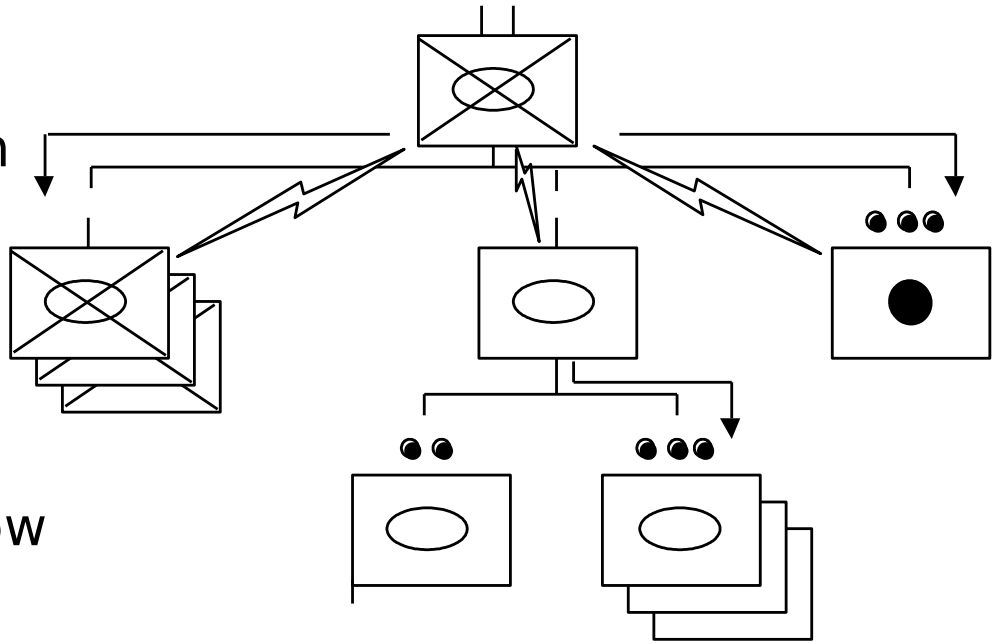


Each domain of interaction provides explicit definition of possible entity interactions.

Each entity may be represented by either a model or man-in-the-loop.

C³I Functionality of CGF Engine

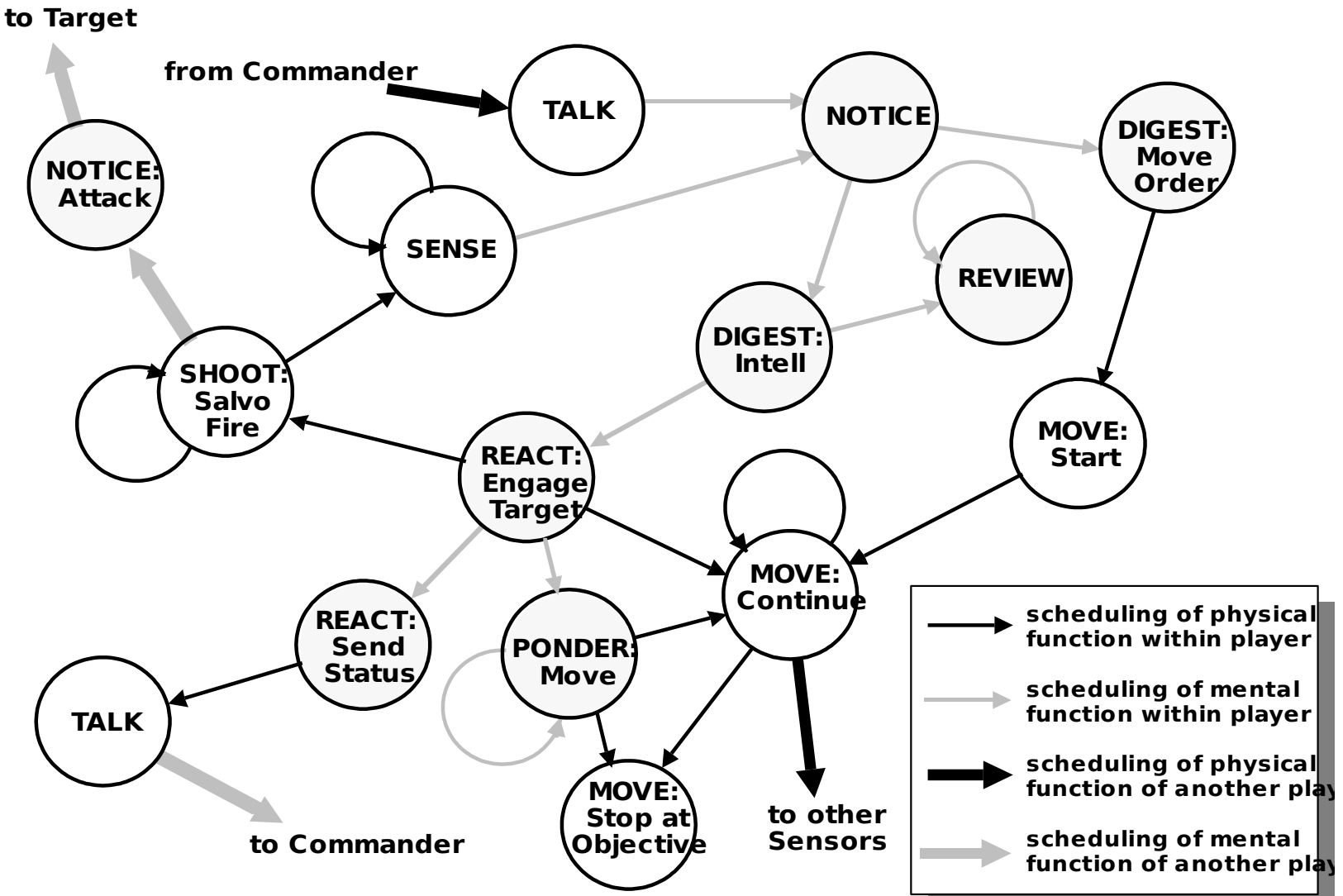
Command and Control is modeled through inter-player resource allocation logic, the use of coordination tactics, and commander/subordinate relationships.



Explicit representation of communications nets allow for:

- control decisions to be made known to commanded entities,
- commanded elements to send status reports up the chain of command, and
- coordination to be shared between entities

JIMM Event Scheduling

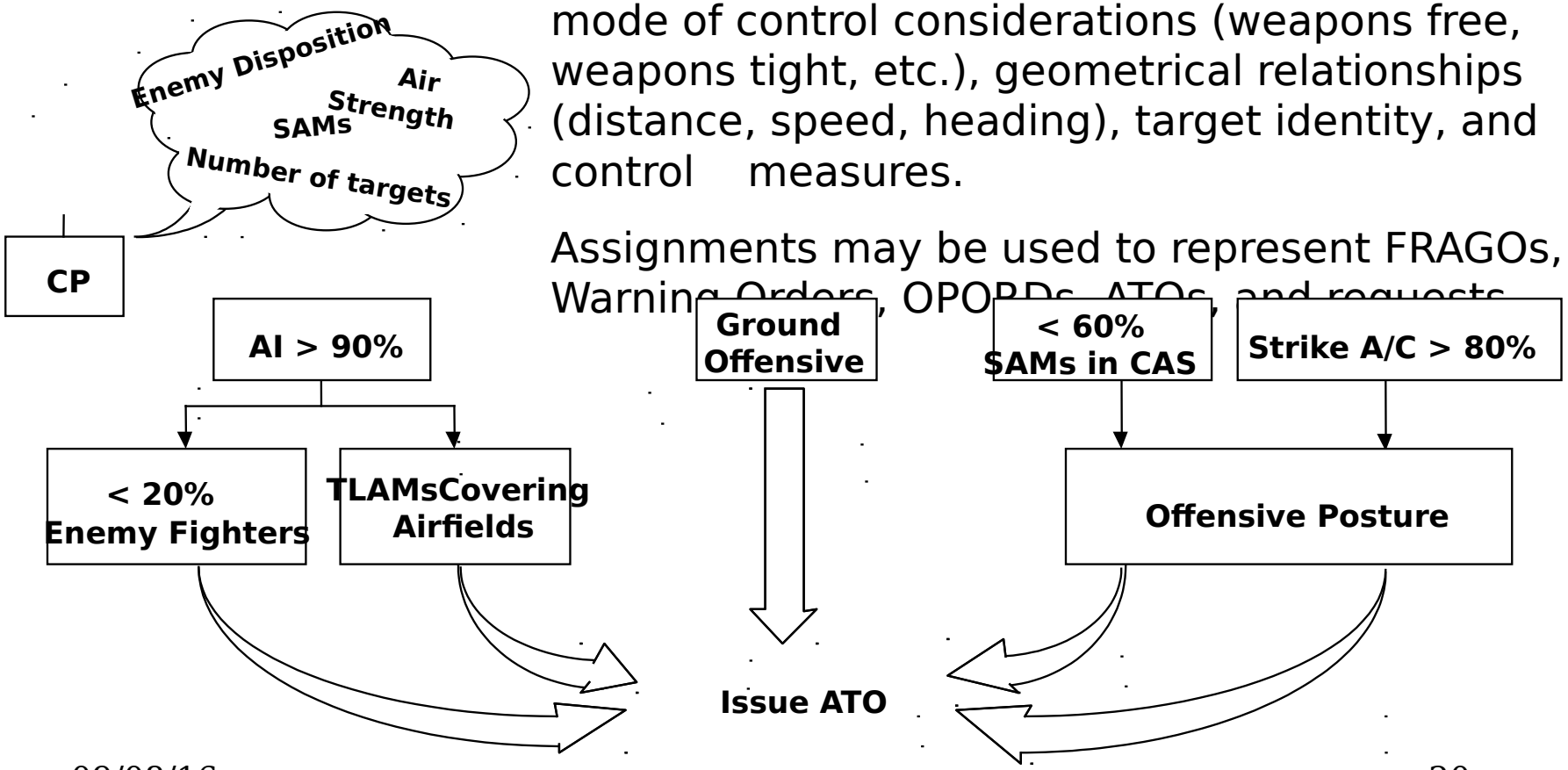


Inter-Player Resource Allocation

The user specifies English-like "filters" to develop rule sets for the allocation of commanded forces against the enemy.

The filters may be based on subordinate loading, subordinate status, mode of control considerations (weapons free, weapons tight, etc.), geometrical relationships (distance, speed, heading), target identity, and control measures.

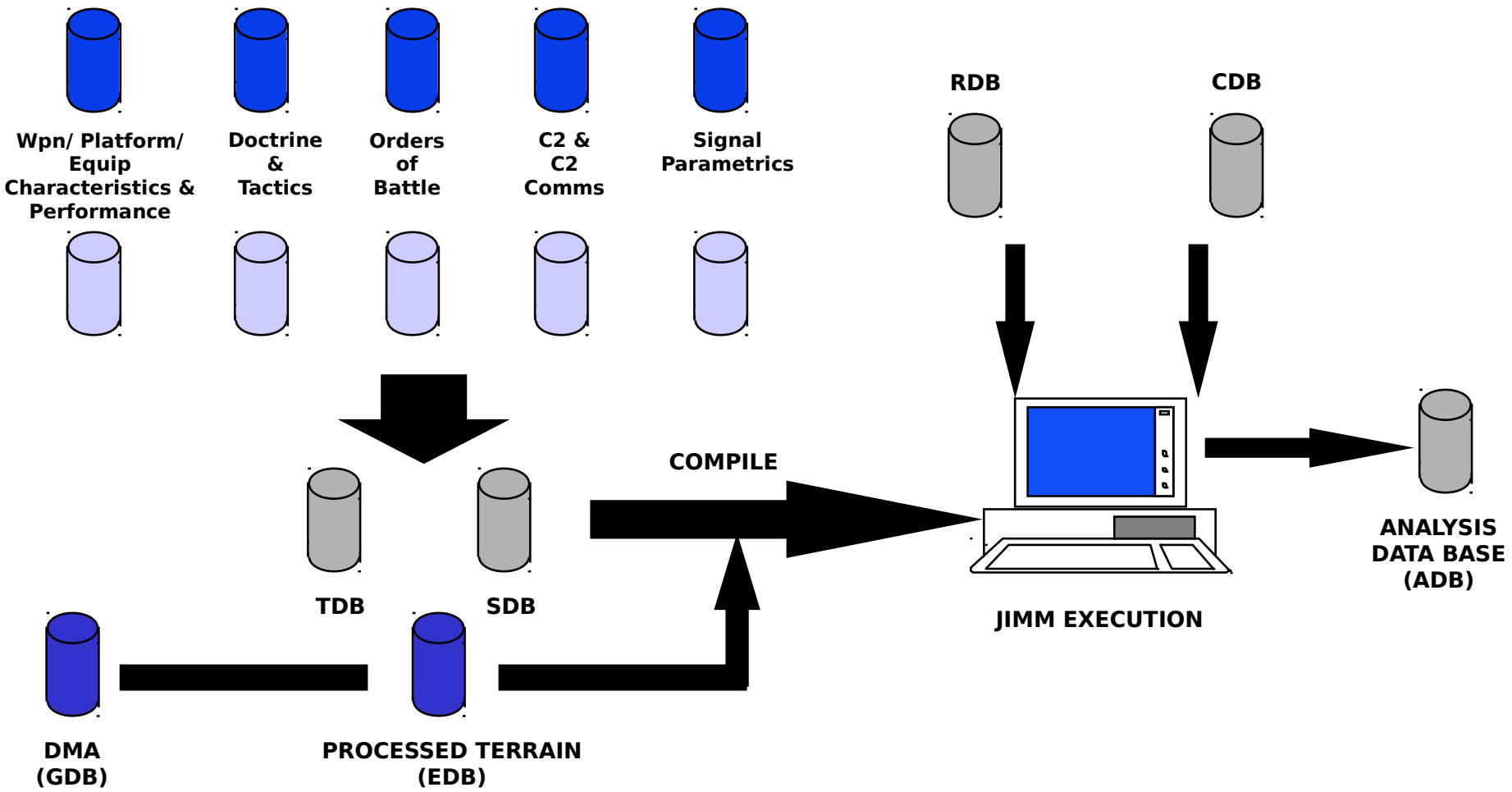
Assignments may be used to represent FRAGOs, Warning Orders, OPORDs, ATOs, and requests



JIMM - Data Defined

	Source	Database	Contents
Session	System Operator	Configuration	System Physical Resources mapped to logical requirements.
Session	SAFOR Operator	Scenario	Intial conditions, including positions, perceptions, missions, orders, etc.
Battlefield	Subject Matter Expert	Type	Characteristics and capabilities of battlefield entities
Battlefield	P2851	Environment	Terrain, features, climate, atmospherics, sunspots, etc.

JIMM Process



Example Time History Data Item

FIRST-DIRECTLY-SEES

PURPOSE Records an initial perception of a target through a sensor owned subject player.

USAGE The target may have been on the perception list of the player. If there due to an indirect perception (FIRST-INDIRECTLY-SEES incident).

Thus, this incident signifies the first time that the player has a perception update/initi target with one of its own sensors. The INITIATES-PERCEPTION-OF Time History incid signifies that this is a brand new perception. If it does not occur, it means that the pla already known about the target from a previously received message.

REFERENCE

See the FIRST-INDIRECTLY-SEES and INITIATES-PERCEPTION-OF Time History data items.

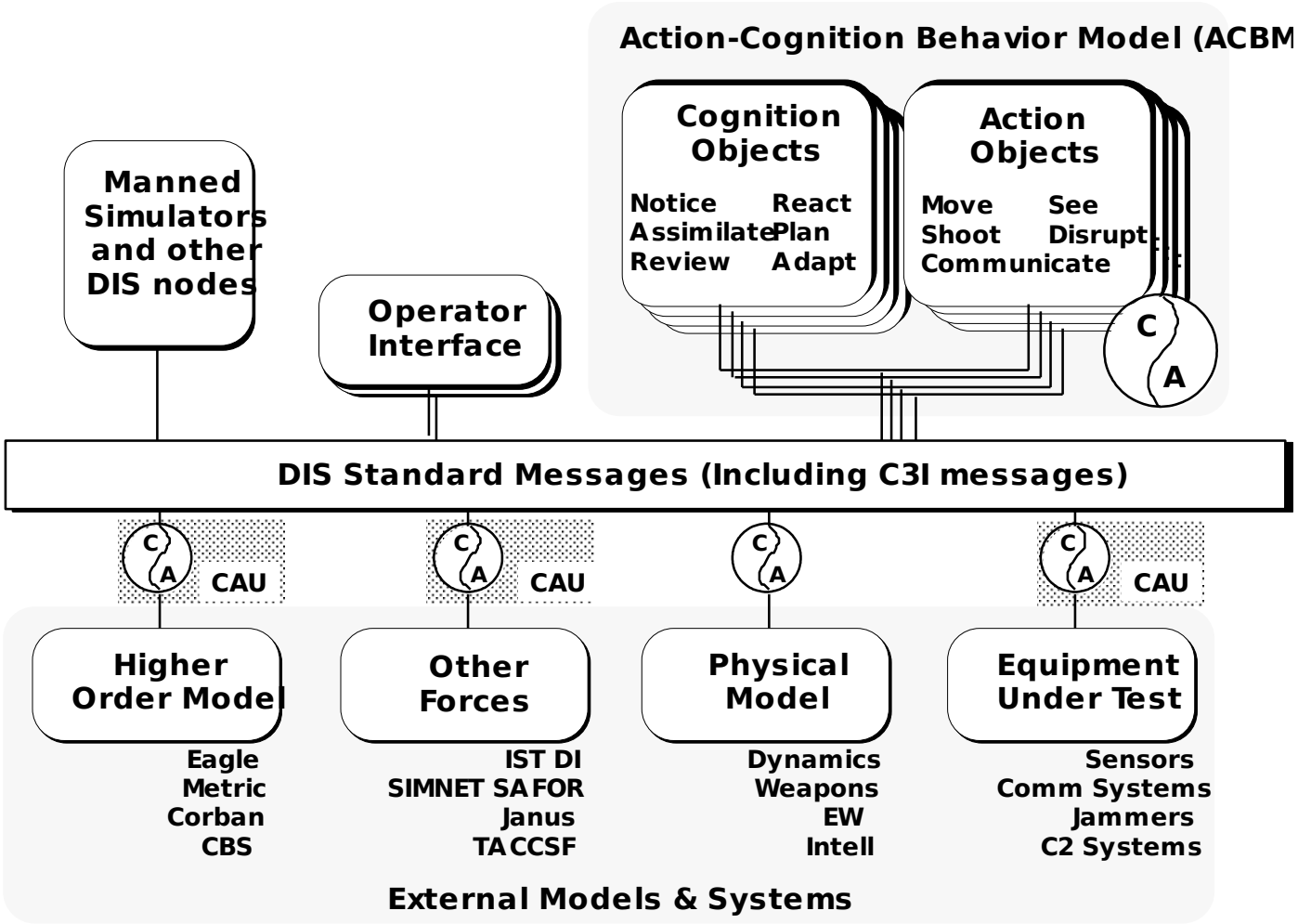
FIRST-DIRECTLY-SEES

<org-name> *<Player-Name>* (**Cluster** *<id>*) **FIRST-DIRECTLY-SEES**
<org-name> *<Player-Name>* (**Cluster** *<id>*)
tgt (x,y,z): *<x-coord.>* **km** *<y-coord.>* **km** *<z-coord.>* **km;**
time: *<past-game-time.>*
...
...

```
4:35.1 Day  0
      6/345 sam-a (Cluster 1) INITIATES-PERCEPTION-OF 21 bomber-a
        and FIRST-DIRECTLY-SEES it
           tgt (x,y,z): 467.9 km -37.0 km 2.737 km; time: 4:35.0
```

...

Architecture - Assets

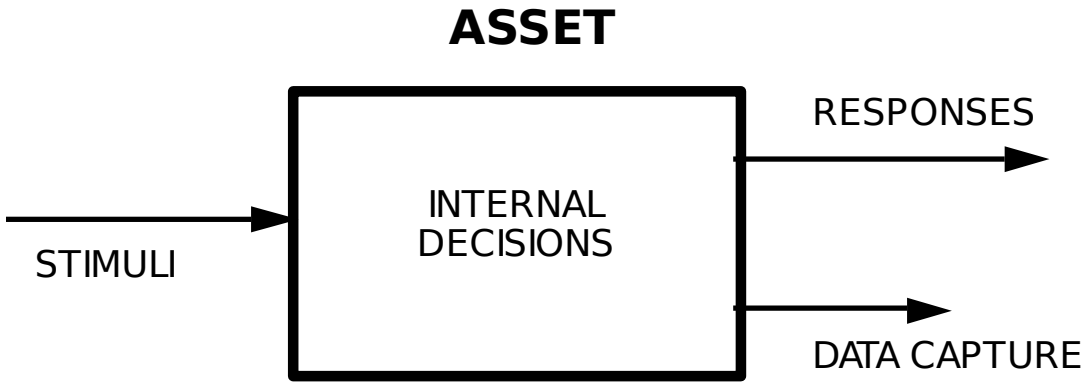


What is an Asset?

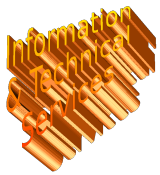
- An asset is a collection of hardware, software, and people that represent some or all of the functions of one or more players, or has some administrative functions.
- An asset's responsibilities can change during the exercise.
- It is important to keep separate the concepts of a player and an asset.
- Assets carry out actions that represent the functions of a player.
- Assets have their own exercise command and control structure and communications.

Stimuli-Decision-Response

- **The modeling of physical actions and cognitive processes is done in response to events**
- **Assets are defined by their stimuli, decisions, and responses.**



stimuli - messages, sensor chances, other input
decisions - internal actions, thought processes
responses - results of decisions, become another asset's stimuli
data capture - for monitoring internal processes



Overview of Asset Interactions

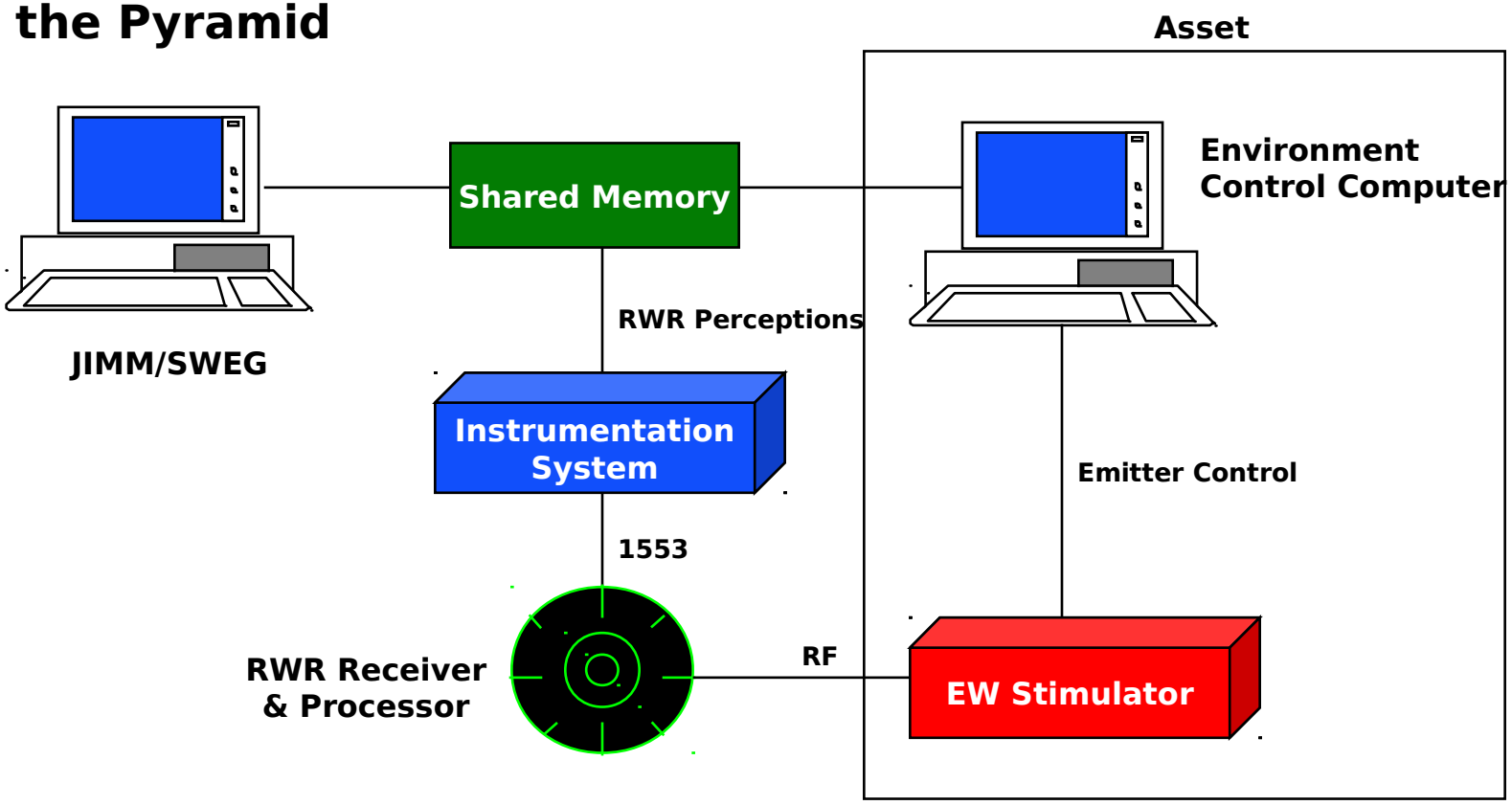
- **Assets interact through a well-defined interface**
- **JIMM has default responsibilities for all player functions not assigned to other assets**
- **Sometimes JIMM will duplicate another asset's responsibility to facilitate a later asset interaction**

Communications between Assets

- Shared memory communications involve two types of information:
  - rapidly changing, frequently updated, read by many data values
  - infrequently changing, read by one asset data value
- Periodic or broadcast data transmission represents the rapidly changing data which includes position, kinematics, and orientation.
- Aperiodic or mailbox messages are used when one asset wants to inform another about an infrequently occurring situation such as weapon firings, births, etc..

JIMM/SWEG Structure For Linking External Assets

- JIMM Can Be Used to Drive External Hardware Stimulators or Threat Simulations
- JIMM Framework Facilitates Linkages to Models Down the Pyramid

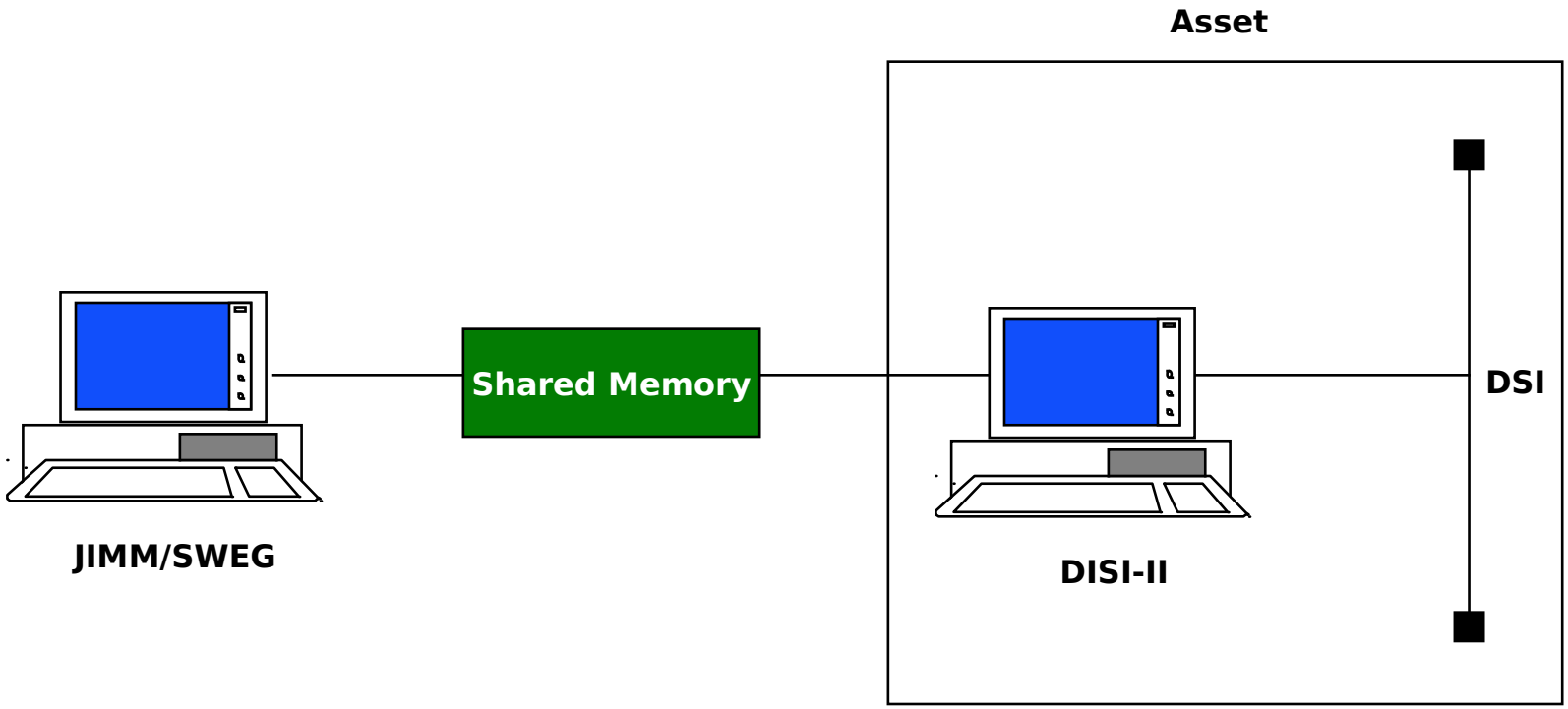


ESAMS Interface to JIMM

- Enhanced Surface-to-Air Missile Simulation (ESAMS) is an Asset similar to other High Fidelity SAM Flyout Simulations Developed by ACETEF
- Multiple ESAMS Assets are Possible
- ESAMS Asset Handles an Entire SAM Engagement from Tracker Turn-on to Missile Intercept
- Tracker, Missile Flyout Kinematics, and Seeker Performance are Modeled at a High Level of Fidelity
- All ESAMS ECM Modes can be Accessed by Using Disruptors in JIMM
- Disruptors in JIMM can be Controlled either Internally or Externally (by an Asset)

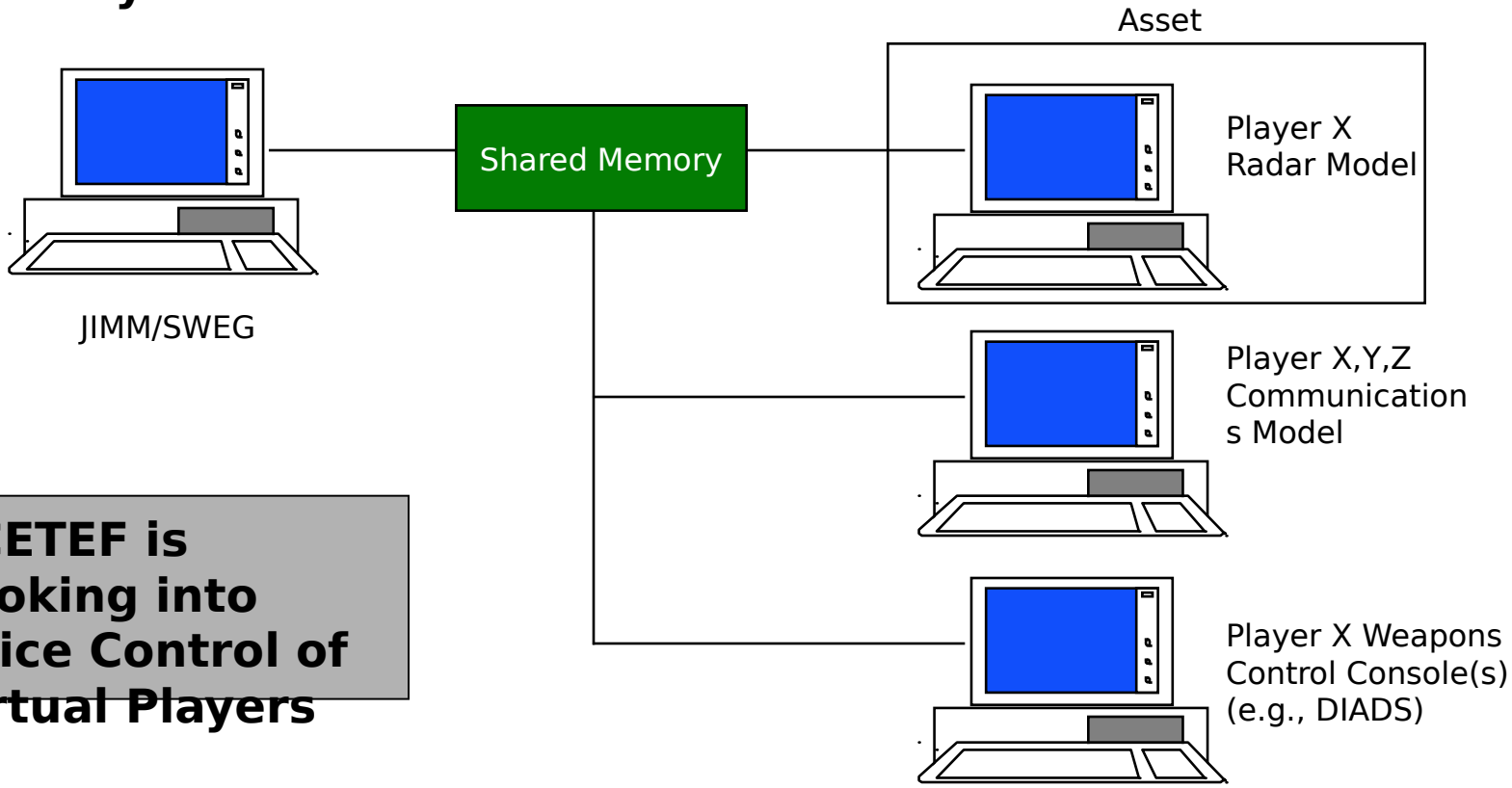
JIMM/SWEG Structure For Linking External Assets

- JIMM can be used to link up external distributed simulations, both DIS and HLA
- JIMM Framework Facilitates Linkages to Models Up the Pyramid



JIMM/SWEG Structure For Linking External Assets

- **JIMM allows for the partial or full external model representation of a player**
- **JIMM Framework Facilitates Linkages to Models Down the Pyramid**



ACETEF is Looking into Voice Control of Virtual Players

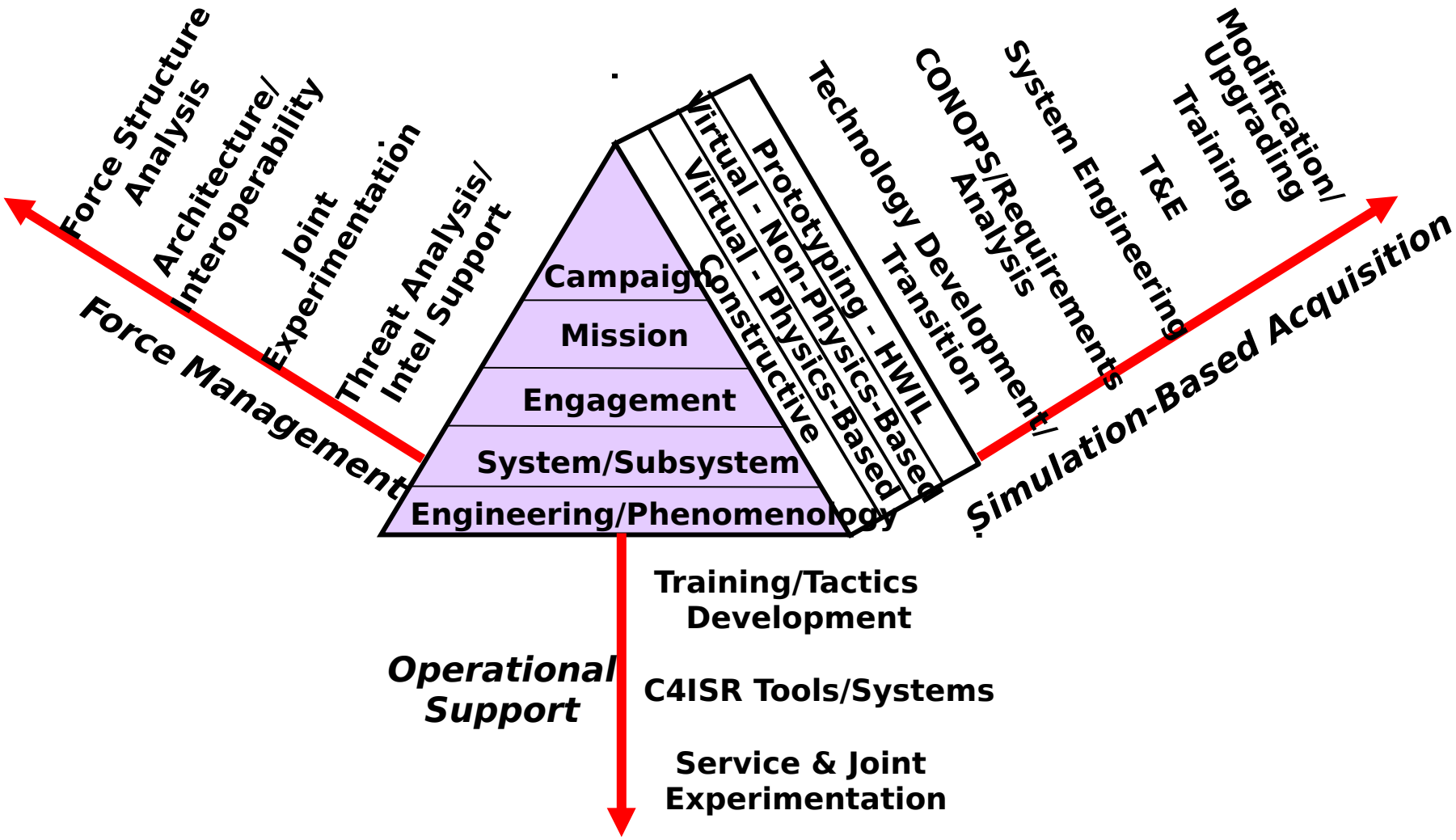
DIADS Overview

- **The Digital Integrated Air Defense System (DIADS) is derived from the REDCAP facility formerly at Calspan in Buffalo, NY**
- **DIADS can be either virtual or constructive, but only at real-time rates**
- **High fidelity representation of a specific threat IADS and an OAR, in particular the C3 structures**
- **Mix of Synthetic Operators or SITLs (Soldiers-in-the-Loop) can perform C2 functions**
  - **Fuse Data from Multiple Source (Radar, ESM, ECM)**
  - **Develop Comprehensive Air Picture**
  - **Identify Hostile Aircraft and Determine Threat of each Target**
  - **Assign the Best Weapon System to the Highest Threat**

DIADS Synthetic Operator

- **OITL (Operator-in-the-loop) can**
  - **Add to or Override Synthetic Operator**
  - **Enable/Disable Synthetic Operator**
- **Synthetic Operator Actions**
  - **Rule-based, defined through Scenario Data**
  - **Statistically Based Reaction Time and Accuracy**
  - **Based on same cues utilized by OITL**
- **Multiple Rule Tables Provided**
  - **Selectable by OITL**
  - **Selected Automatically by Events**

Many Dimensions Of Defense MS&A



MS&A In Air Warfare Analysis

- **Basics Of Analysis:**
  - **Probability and Statistics; Problem Solving**
- **Stochastic Models:**
  - **Weapons Assessment Model (WAM)**
- **Dynamic Time Stepped Simulation:**
  - **Air To Air System Performance Evaluation Model (AASPEM)**
  - **Enhanced Surface-to-Air Missile Simulation (ESAMS)**
- **Object Oriented, Event Driven Simulation:**
  - **Air Base Attack Model (ABATAK)**
  - **JIMM**
  - **SWEG**
- **Process Simulation:**
  - **COMBAT IV Theater Campaign Simulation**

- Capture Items of Interest at Right Level of Fidelity

- Drill Down to Specific Causes & Effects

- Train Analysts

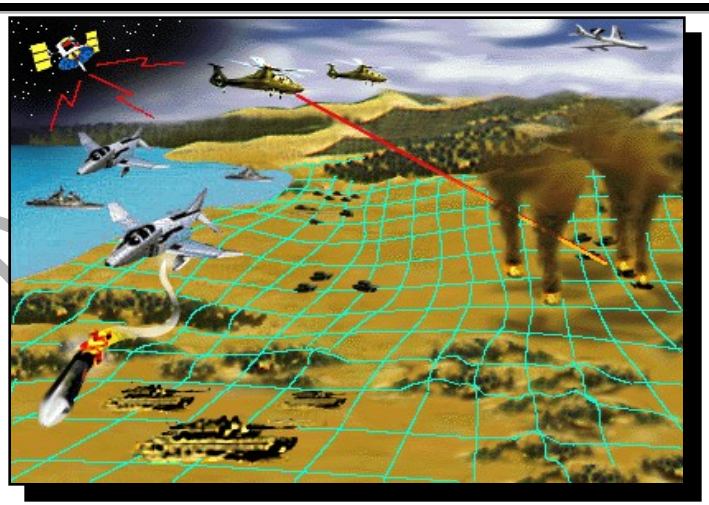
- Trace System Requirements

Test & Evaluation Support

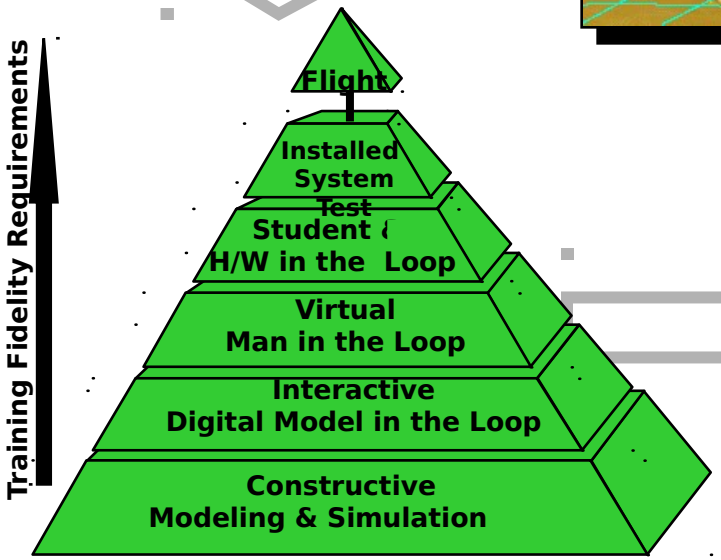
- **Test Concept Development**
- **Test Planning**
- **Test Execution**
- **Test Reporting**
- **Modeling and Simulation Support**
- **Study Support for AFSAA, AFOTEC, ACETEF, other Government Agencies and contractors**

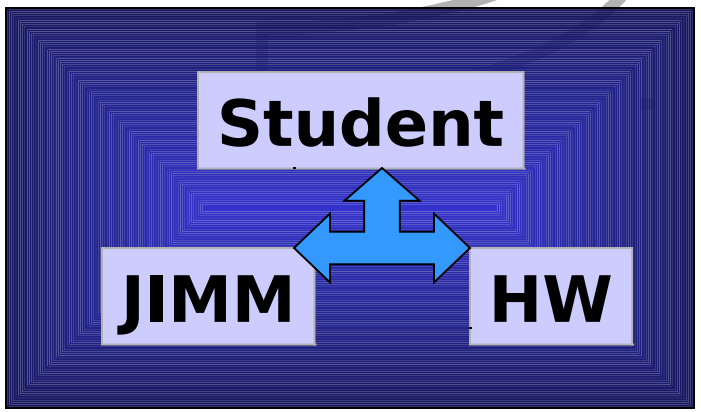
JIMM As Training Controller

The Training Problem



Training Accomplished

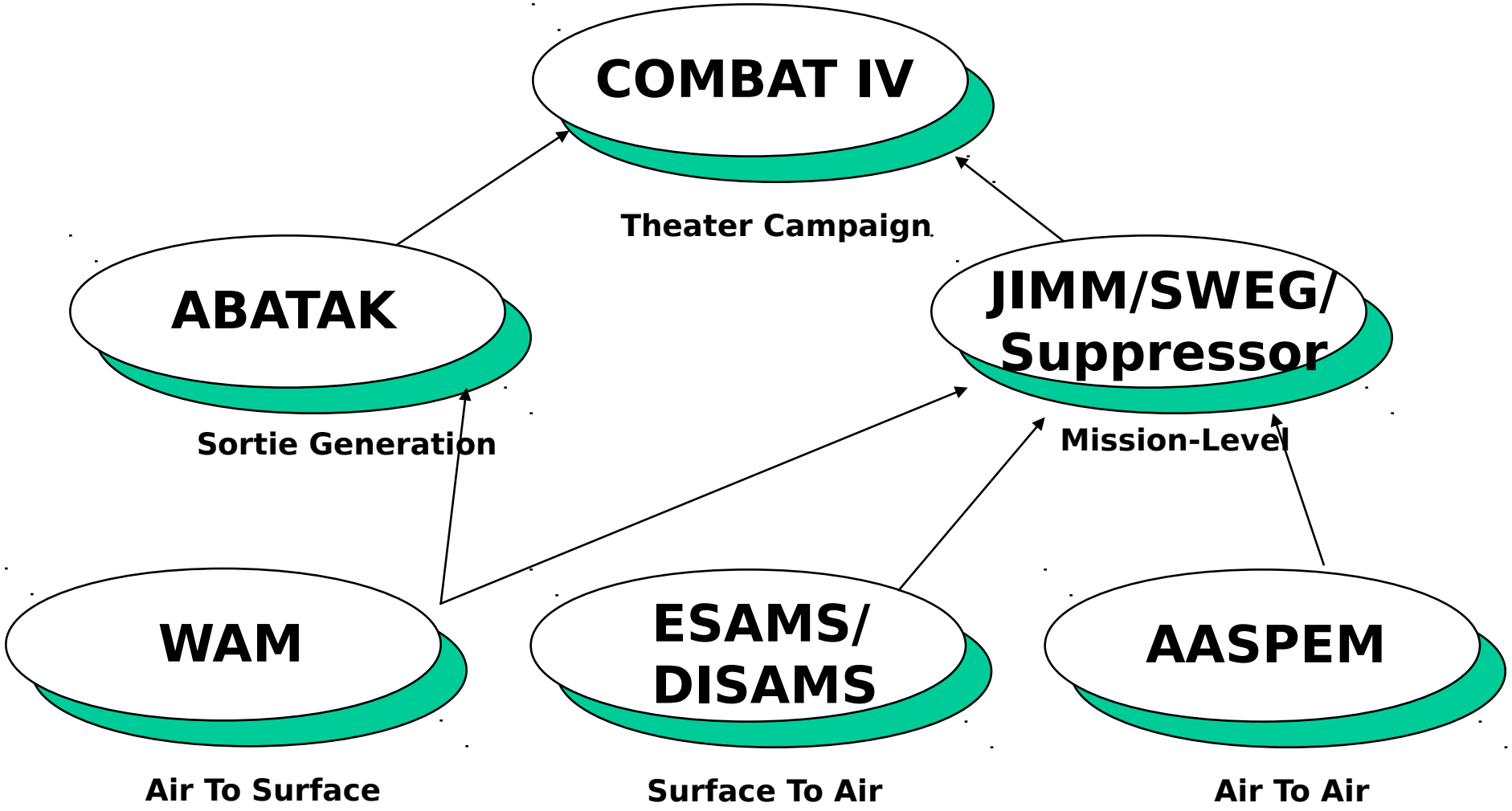

Training Fidelity Requirements
Flight
Installed System Test
Student / H/W in the Loop
Virtual Man in the Loop
Interactive Digital Model in the Loop
Constructive Modeling & Simulation



Select the Training Fidelity

JIMM Drives the Training Exercise

Linked Family Of Air Warfare Models



Advanced Technology Enables Advanced MS&A

- **Object Oriented Design, Architecture & Conceptual Modeling:**
  - **Software Reuse, Model Libraries & Model Interoperability**
  - **Better V&V, and Easier Construction of New Simulations & Environments**
- **Realistic Representation of Players:**
  - **Cognitive Modeling**
  - **Adaptive & Role-Based Behavior**
  - **Nonlinear Dynamics (“Chaos”)**
- **Agent-Based Simulation Processes**
- **Distributed Simulation on Workstation-Class Hosts**
- **Mixed-Fidelity Simulations**
- **High Fidelity Visualization & Operational Backgrounds**
- **Graphical User Interfaces & User/Analyst-Friendly Tools**
- **Hardware-in-the-Loop For Hard-to-Model Objects & Assured Fidelity**
- **Integrated Tool Sets**

Summary

- **JIMM Provides a Robust, Operationally Realistic Environment in Which to Support Decision Making at the JFACC Level and Below**
- **JIMM's C2 Processing Provides a Medium Level of Fidelity with a Very Robust Modeling Capability**
- **If Additional Fidelity is Required, Assets Provide a Link to Manned Simulators, Hardware Stimulators, and Computer Simulations**
- **JIMM/SWEG have been used in Support of:**
  - **Requirements Analysis**
  - **Simulation-Based Acquisition**
  - **Test & Evaluation**
  - **Operational Concepts Development**